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Our Case No. 4325
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10/088183
JC13 Rec'd PCT/PTO 15 MAR 2002

Description

Hard Sintered Compact Throwaway Tip

5 Technical Field

The present invention relates to an indexable insert in which a sintered body that contains cubic boron nitride is bonded to a tool substrate.

Background Art

10 A sintered material made by sintering fine cubic boron nitride using various binders shows excellent performance when used to cut hard iron-family metals and cast iron.

Figures 5 and 6 show examples of conventional tools disclosed in Japanese Published Unexamined Utility Model Application Jitsukaihei 3-
15 93004. A hard sintered body indexable insert 51 shown in Fig. 5 is obtained by forming a concave hollow at a corner part of a tool substrate 55, thereafter fitting a composite hard sintered body that consists of a hard sintered body 52 and a cemented carbide support 53 thereinto, and brazing them. Cutting edges are formed at the upper and lower surfaces of the hard sintered body
20 indexable insert 51.

Likewise, in a hard sintered body indexable insert 51 shown in Figure 6, a composite hard sintered body that consists of a hard sintered body 52 and a cemented carbide support 53 is brazed to the overall side face of a corner part of

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a tool substrate 55. As in the case shown in Figure 5, cutting edges are formed at the upper and lower surfaces of the hard sintered body indexable insert 51.

The plurality of cutting edges of the upper and lower surfaces of the tip can be simultaneously ground by disposing the composite hard sintered body as shown in Figures 5 and 6, through one grinding step. Machining costs for each cutting edge of the hard sintered body 52 therefore, can be reduced, and an inexpensive tool can be provided.

However, the drawback of the constructed conventional tool is that it is difficult to manufacture a less expensive indexable insert, or achieve high tool performance.

In other words, cracks and breakage will occur in the hard sintered body 52 if the tool of Figure 5 is used under severe conditions. The cracks and breakage run through the hard sintered body 52 with low strength, and reach an unused corner opposite the corner that has been used. As a result, a problem occurs in which the unused corner can no longer be used.

Further, in the tool of Figure 6, the composite hard sintered body consisting of the hard sintered body 52 and the cemented carbide support 53 is brazed only in a direction to be sheared with respect to cutting resistance (main cutting force). Therefore, there is the possibility that the composite hard sintered body comes off under severe conditions because of insufficient brazing strength.

Further, other conventional examples of the hard sintered body indexable insert are shown in Figures 3 and 4. In Fig. 3, the hard sintered

body 52 is sintered with the cemented carbide support 53 and obtained as a cubic boron nitride composite hard sintered body in a state of being backed with the cemented carbide support 53. This composite hard sintered body is brazed to a seating groove 56 of the tool substrate 55 through a brazing alloy composed chiefly of Ag and Cu. Thereafter, only a ridge of the hard sintered body 52, which serves as a cutting edge, is ground, or is ground simultaneously with a ridge of the tool substrate 55, and thus the hard sintered body indexable insert 51 shown in Fig. 3 is obtained.

In Figure 4, a plurality of composite hard sintered bodies are brazed to the upper surface of the tool substrate 55, and are ground. Thereby, a plurality of cutting edges are simultaneously ground in one step. This makes it possible to reduce machining costs for each cutting edge of the hard sintered body, and makes it possible to provide a tool at low manufacturing cost for the single cutting edge.

In order to manufacture a less expensive hard sintered body indexable insert such as the tools shown in Figures 3 and 4, there is a need to further integrate the composite hard sintered body with respect to the single tool substrate 55. Specifically, there is a need to dispose the composite hard sintered body not only at the corner part of the upper surface of the hard sintered body indexable insert 51 but also at the nose part of the lower surface of the hard sintered body indexable insert 51.

However, a brazing alloy of a soft metal chiefly composed of Ag and Cu has been conventionally used to bond such a composite hard sintered body.

Brazing is carried out by heating it to a temperature such that the liquid phase of the brazing alloy appears in the atmosphere while using a high-frequency heating machine or the like. It was difficult to bond multiple composite hard sintered bodies in terms of positioning for the following reasons.

5 For example, a composite hard sintered body is brazed to the corner part of the upper surface of the hard sintered body indexable insert by use of a conventional brazing alloy, and thereafter it is turned upside down. While heating is being carried out by the high-frequency heating machine so as to braze the composite hard sintered body to the corner part of the upper surface,
10 a brazing alloy of the lower surface of the composite hard sintered body, which has been brazed, is also heated and softened. Therefore, in the composite hard sintered body of the lower surface, which has been brazed, there is a case in which the position thereof deviates as a result of gravity, or in which the composite hard sintered body itself falls from the tool substrate. Therefore, it
15 was substantially impossible to complete the tool.

In contrast, in order to remove a bond interface between the hard sintered body and the cemented carbide support, the idea of bonding the hard sintered body onto the tool substrate without the cemented carbide support has been proposed. This tool structure is disclosed in Japanese Published
20 Unexamined Patent Application Tokukaihei 11-320218.

It is a hard sintered body indexable insert in which a hard sintered body of diamond or of cubic boron nitride is brazed directly to a tool substrate in a vacuum or in an inert gas atmosphere by use of a brazing alloy that constitutes

respect to the thickness of the hard sintered body indexable insert, and the length of the cutting edge of the hard sintered body or of the composite hard sintered body is within the range of 0.5 mm to 4.0 mm.

Said bonding layer of the brazing alloy is characterized by containing Ti
5 and/or Zr by 0.5 to 65 wt % and further containing Cu.

A manufacturing method for manufacturing this hard sintered body indexable insert is described as follows. A brazing alloy with which a hard sintered body or a composite hard sintered body that contains cubic boron nitride by 20 vol % or more is brazed to a seating groove formed at a corner of
10 the tool substrate is made paste-like by mixing a powdery brazing alloy that contains Ti and/or Zr by 0.5 to 65 wt % and further contains Cu with an organic binder.

Thereafter, the hard sintered body or the composite hard sintered body is bonded to the seating groove of the upper surface of the tool substrate
15 through the paste-like brazing alloy, a solvent component in the organic binder is then evaporated, and the hard sintered body or the composite hard sintered body is temporarily fastened. Thereafter, the hard sintered body or the composite hard sintered body is bonded to the seating groove of the lower surface of the tool substrate through the paste-like brazing alloy, the organic
20 binder is then evaporated, and the hard sintered body or the composite hard sintered body is temporarily fastened. Thereafter, the hard sintered body indexable insert in which the hard sintered body or the composite hard sintered body is temporarily fastened to the upper and lower surfaces is heated, brazed,

and firmly bonded in a vacuum or in an inert gas atmosphere.

Brief Description of Drawings

Figure 1 shows a front view and a sectional view of a hard sintered body
5 indexable insert according to an embodiment of the present invention.

Figure 2 shows a front view and a sectional view of a hard sintered body
indexable insert according to another embodiment of the present invention.

Figure 3 shows a front view and a sectional view of a conventional
sintered body indexable insert.

10 Figure 4 shows a front view and a sectional view of another
conventional sintered body indexable insert.

Figure 5 shows a front view and a sectional view of still another
conventional sintered body indexable insert.

15 Figure 6 shows a front view and a sectional view of still another
conventional sintered body indexable insert.

Best Mode for Carrying Out the Invention

The present inventors have earnestly sought a method for
inexpensively manufacturing a hard sintered body indexable insert that
20 contains cubic boron nitride without compromising the performance of a tool.
As a result, a hard sintered body indexable insert was manufactured in which a
hard sintered body that contains cubic boron nitride by 20 vol % or more is
bonded to a seating groove formed at a corner of a tool substrate, and a ridge of

Additionally, since there is a vertical brazed plane to main cutting force among brazing planes, the hard sintered body 2 does not fall off by a shearing force. The tool substrate 5 may be made of any material so long as it is higher in strength than the hard sintered body 2. However, cemented carbide that has a small difference in thermal expansion with the hard sintered body 2 is preferable in order to prevent cracks and breakage of the hard sintered body 2 caused by heating when brazed.

If the thickness of the tool substrate 5 sandwiched between the pair of seating grooves 6 reaches less than 30% with respect to the thickness of the hard sintered body indexable insert 1, there is an increased possibility that the cutting resistance that occurs while cutting will concentrate on the corner of the seating groove 6 so as to cause breakage from the corner of the seating groove 6 while cutting. On the other hand, if it exceeds 90%, the thickness of the part of the hard sintered body 2 will thin, causing the flank wear of the cutting edge to easily exceed the layer of the hard sintered body 2. In this case, the flank wear progresses rapidly, and increases possibility of a reduced tool life.

Therefore, the thickness of the tool substrate 5 sandwiched between the pair of seating grooves 6 is desirably within the range of 30% to 90% with respect to the thickness of the hard sintered body indexable insert 1.

More desirably, it is within the range of 30% to 60%, in consideration of the composite hard sintered body with which the cemented carbide support 3 is backed.

The thickness of each hard sintered body 2 is desirably 0.8 mm to 1.6 mm. If the thickness is less than 0.8 mm, a brazing area in the thickness direction decreases. If the hard sintered body 2 whose thickness exceeds 1.6 mm is brazed to the upper and lower surfaces, the thickness of the tool substrate 5 thins, and the possibility of breakage to occur from the corner of the seating groove 6 will increase when cutting under severe conditions.

Thus, in order to secure the thickness of the hard sintered body 2

without thinning the part of the tool substrate 5, the structure of Figure 2 in which the hard sintered body 2 is bonded directly to the tool substrate 5 through the bonding layer 4 is preferable to the conventional composite hard sintered body backed with the cemented carbide support 3.

5 If the cutting-edge length of the hard sintered body exceeds 4.0 mm, the length from the bottom corner of the seating groove 6 to the cutting edge is increased, and an arm length of moment become long. Accordingly, large stress caused by the cutting resistance concentrates on the corner of the seating groove 6, thus enhancing the possibility that breakage will occur from this
10 seating groove corner while cutting. If the cutting-edge length is less than 0.5 mm, there will be frequent occurrences of which a cutting-edge length necessary for cutting cannot be obtained. Therefore, desirably, the cutting-edge length of the hard sintered body 2 is within the range of 0.5 mm to 4.0 mm.

15 On the other hand, since the pair of hard sintered bodies 2 are disposed on the upper and lower surfaces of the hard sintered body indexable insert 1, the execution of one process for forming the cutting edge at the corner part of the hard sintered body 2 (i.e., process for grinding two sides between which the corner part is sandwiched and grinding one part) makes it possible to form the
20 two upper and lower cutting edges, and makes it possible to greatly reduce tool-machining costs for one cutting edge of the hard sintered body 2.

Further, for the same reason as above, since the number of pairs of upper and lower hard sintered bodies 2 is increased by disposing them at the

other corner parts, machining costs for one cutting edge of the hard sintered body 2 or the cost of the tool substrate 5 falls. This increasingly reduces the manufacturing costs for one cutting edge of the hard sintered body 2. Therefore, it is more desirable to dispose of the pair of upper and lower hard sintered bodies 2 at all corner parts, which can be used for cutting-edges.

On the other hand, the present inventors have found that the hard sintered body 2 or the composite hard sintered body can be brazed to the upper and lower surfaces of the tool substrate 5 according to the following method.

In the present invention, a brazing alloy that contains Ti or Zr is used. This brazing alloy conventionally has been used for Ti bonding or ceramic bonding, and rarely has been used for tools as in the present invention. Ti or Zr has a high melting point, and therefore brazing temperature becomes high. Additionally, Ti or Zr is an easily oxidized metal, and therefore brazing cannot be carried out in the atmosphere. The brazing must be carried out at least in an inert gas or in a vacuum. Therefore, since the positioning of a hard sintered body or a composite hard sintered body cannot be operated directly, it has been considered that practical application cannot be accomplished from the viewpoint of cost.

However, as a result of studies, the present inventors have found that, if a brazing alloy of the present invention is used, brazing can be carried out merely by inserting the material into an airtight container and by appropriately controlling the temperature, with high positioning accuracy and without allowing a lower hard sintered body to fall off. Concerning the

composition of the brazing alloy after being brazed, easily evaporable components tend to evaporate and decrease because the brazing temperature is high.

A more explanatory description provides that, a paste-like brazing alloy
 5 is prepared by mixing a powdery brazing alloy that contains 0.5 to 65 wt % Ti and/or Zr and that further contains Cu with an organic binder. Thereafter, a hard sintered body 2 or a composite hard sintered body is bonded to a part of a seating groove 6 formed in the upper surface of a tool substrate 5 through the paste-like brazing alloy. Herein, any material can be used as the organic
 10 binder provides that it has moderate viscosity, such as that of glue, of gelatin, or of terpeneol, and provided that a solvent component of the binder evaporates at a relatively low temperature. The "low temperature" mentioned here means temperature less than a solidus line or less than a liquidus line of the brazing alloy component, and indicates the temperature according to which
 15 such oxidation as changing the quality of the brazing alloy does not occur.

Thereafter, the indexable insert in which the hard sintered body 2 or the composite hard sintered body 8 is bonded through the paste-like brazing alloy is heated or is left in the atmosphere at less than the temperature at which a liquid phase appears from the brazing alloy and in the temperature range in
 20 which the quality of the brazing alloy does not change and is not oxidized. The solvent component of the organic binder is evaporated from the paste-like brazing alloy in this manner. Thus, the hard sintered body 2 or the composite hard sintered body 8 can be temporarily fastened to the tool substrate 5 by the

Desirably, the composition of the brazing alloy is within the aforementioned range not only from the viewpoint of the positioning in the

Further, a coating layer is formed on the surface of the thus produced
20 hard sintered body indexable insert 1 according to a physical vapor deposition
method or a chemical vapor deposition method. That is, there is formed a
coating layer comprising at least one element selected from the group
consisting of elements belonging to groups IVa, Va, VIa in the periodic table

and elements Al, Si, and B, or at least one compound selected from the group consisting of nitride, carbide, or oxide of at least one metal selected from this group, and their solid solutions. In this case, the coating layer is preferable because the cutting performance of the tool is improved by the coating, and
 5 coating costs for one cutting edge of the hard sintered body can be greatly reduced without compromising tool performance.

As shown in Figure 1, a recess 7 is provided at the brazing part of the composite hard sintered body of the tool substrate 5. This is effective in the fact that the composite hard sintered body and the tool substrate can be brazed
 10 with excellent dimensional accuracy. The same applies to the hard sintered body shown in Figure 2.

Additionally, in the present invention, it is effective to mark a numeral on each corner of the edge. The conventional indexable insert using the hard sintered body merely uses one or two corners. In contrast, the indexable
 15 insert of the present invention is effective because the blade exists on the upper and lower surfaces, and a judgment regarding whether it has been used or not can be easily made by the numeral.

(Embodiment 1)

20 The hard sintered body indexable insert 1 shown in Figure 2 was made. It was made for a purpose to examine an its effect on cutting performance and on durability by the thickness of the part of the tool substrate 5 between a pair of seating grooves 6. The pair of upper and lower seating grooves 6 used to

bond the hard sintered body 2 was provided at each corner of the tool substrate corner, and the depth of the seating groove 6 was variously changed. These are shown in Table I.

The entire thickness of the hard sintered body indexable insert 1 was
5 4.76 mm in each sample, and the length of the cutting-edge was 2.4 mm in each sample.

Table I

Sample No.	Thickness of one hard sintered body (mm)		Thickness of tool substrate part between seating grooves (mm)	Ratio (%) of thickness of tool substrate part between seating grooves to entire thickness of indexable insert
1	0.15	Comparative example	4.36	91.6
2	0.25	Present invention	4.16	87.3
3	0.45	Present invention	3.76	79.0
4	1.0	Present invention	2.66	55.9
5	1.55	Present invention	1.56	32.8
6	1.75	Comparative example	1.16	24.3
7	4.76	Comparative example	---	---

(Note) Sample No. 7 is an indexable insert in which the hard sintered body was brazed to the whole area of the nose R side of the tool substrate 5 and the entire thickness reached 4.76 mm, for a comparison with the present invention. The thickness of the bonding layer after brazing was 0.05 mm in each sample.

Referring to the manufacturing method, a paste-like brazing alloy was first prepared by mixing a powdery brazing alloy which contains 25 wt % Ti and 25 wt % Zr and the remainder of Cu and inevitable impurities with terpeneol.

Thereafter, the hard sintered body 2 that contains cubic boron nitride by 50 vol % was bonded through the paste-like brazing alloy to a part of the seating groove 6 of the upper surface of the tool substrate 5 in which the depth of the seating groove 6 has been variously changed. Thereafter, in order to temporarily fasten the hard sintered body 2 onto the tool substrate 5 by

evaporating a solvent component of a binder, the hard sintered body indexable insert 1 was dried in an atmospheric atmosphere furnace of 100°C.

After drying was completed, the seating groove was turned upside down so that the lower surface was directed upward, and the hard sintered body 2
5 was temporarily fastened to the turned seating groove according to the same procedures.

Thereafter, this hard sintered body indexable insert 1 was subjected to brazing in a vacuum atmosphere of 1.333×10^{-2} Pa and at a temperature of 850°C. Thereafter, in order to form a cutting edge at a ridge of the hard
10 sintered body 2, the ridge was ground, thereafter a coating layer of TiAlN whose thickness is $2.0 \mu\text{m}$ was formed on the surface of the hard sintered body indexable insert 1 according to the PVD method, and the cutting performance thereof was evaluated.

Table II shows the results.

Table II

Sample No.		Thickness of one hard sintered body (mm)	Ratio (%) of thickness of tool substrate part between seating grooves to entire thickness of indexable insert	Cutting time until breakage (min)
1	Comparative example	0.15	91.6	8.0
2	Present invention	0.25	87.3	11.5
3	Present invention	0.45	79.0	12.8
4	Present invention	1.0	55.9	15.2
5	Present invention	1.55	32.8	14.9
6	Comparative example	1.75	24.3	2.0
7	Comparative example	4.76	---	15.0

(Note)

Workpiece: Hardened steel that has six grooves in the longitudinal direction (SCM415)

5 Hardness of workpiece: $H_{RC}62$

Cutting speed of workpiece: 200 (m/min)

Depth of cut: 0.5 (mm)

Tool feed rate: 0.1(mm/rev)

10 As a result, the amount of flank wear exceeded the thickness of the hard sintered body 2 while cutting using the tool of sample No. 1 in which the hard sintered body 2 is thin, therefore wear rapidly progressed, cutting resistance increased, and breakage occurred in the cutting edge in a short time. In the tool of sample No. 6 in which the thickness of the tool substrate 5 is thin, stress
15 during the cutting concentrated on the corner of the seating groove, and

breakage occurred from the corner at the beginning of the cutting without resisting the stress.

In sample No. 7 in which the hard sintered body 2 is brazed to the overall side face of the tool substrate 5, cracks in the upper surface of the tool
5 that occurred by the cutting evaluation ran through the hard sintered body 2 brazed to the entire side face, and reached the lower surface of the tool. As a result, the corner of the lower surface of the tool, which was an unused side, was no longer available.

In contrast, in the tools of sample Nos. 2 through 5 of the present
10 invention, neither breakage of the tool substrate during cutting, nor rapid flank wear, nor immediate breakage of the cutting edge occurred in the cutting test, and cutting could be carried out during its long life. Additionally, after the use of the upper cutting edge of the hard sintered body, the performance of the tool was not impaired, preventing breakage of the cutting edge to run to the
15 lower surface.

(Embodiment 2)

The hard sintered body indexable insert 1 shown in Table III was made to examine an influence exerted on cutting performance and on durability by
20 the length of the cutting edge of the hard sintered body 2. That is, in the hard sintered body indexable insert 1 shown in Table III, a pair of upper and lower sintered bodies 2 was bonded at each corner of the tool substrate, and the cutting-edge length of the hard sintered body 2 was variously changed.

The entire thickness of the hard sintered body indexable insert 1 was 4.76 mm in each sample, and the thickness of the tool substrate between the seating grooves was 2.66 mm in each sample.

Table III

Sample No.		Length of cutting edge of hard sintered body (mm)
8	Comparative example	0.3
9	Present invention	0.5
10	Present invention	1.0
11	Present invention	2.5
12	Present invention	4.0
13	Comparative example	4.3

5 A paste-like brazing alloy was first prepared by mixing a powdery brazing alloy which contains 2 wt % Ti and 26 wt % Cu and the remainder of Ag and inevitable impurities with gelatin.

Thereafter, the hard sintered body 2 that contains cubic boron nitride by 65 vol %, in which the length of the cutting edge has been variously changed,
 10 was bonded through the paste-like brazing alloy to a part of the seating groove 6 of the upper surface of the tool substrate 5. Thereafter, in order to temporarily fasten the hard sintered body 2 onto the tool substrate 5 by evaporating a solvent component of a binder, the hard sintered body indexable insert 1 was dried in an atmospheric atmosphere furnace of 80°C.

15 After drying was completed, the seating groove was turned upside down so that the lower surface thereof was directed upward, and the hard sintered body 2 was temporarily fastened to the turned seating groove according to the

same procedures.

Thereafter, the hard sintered body indexable insert 1 was brazed in an argon atmosphere and at a temperature of 830°C such that parts to be brazed do not come in contact with other materials. Thereafter, in order to form a cutting edge at a ridge of the hard sintered body 2, the ridge was ground, and the cutting performance thereof was evaluated.

Table IV shows the results.

Table IV

Sample No.		Length of cutting edge of hard sintered body (mm)	Cutting time until breakage (min)
8	Comparative example	0.3	0.9
9	Present invention	0.5	13.1
10	Present invention	1.0	13.5
11	Present invention	2.5	13.3
12	Present invention	4.0	13.2
13	Comparative example	4.3	1.0

(Note)

Workpiece: Hardened steel that has four grooves in the longitudinal direction (SUJ2)

Hardness of workpiece: $H_{RC}63$

Cutting speed of workpiece: 180 (m/min)

Depth of cut: 0.4 (mm)

Tool feed rate: 0.12(mm/rev)

As a result, in the tool of sample No. 8 in which the cutting edge of the hard sintered body 2 is short, chipping occurred in the vicinity of the boundary between the hard sintered body 2 and the tool substrate 5 while cutting

because the cutting edge of the hard sintered body 2 was short. This caused breakage at the beginning of the cutting, and made it impossible to continue the cutting operation.

In the tool of sample No. 13 in which the cutting edge is long, the length
5 of the part of the tool substrate 5 between the upper and lower seating grooves 6 is long, and therefore there is considerable stress at the bottom corner of the seating groove 6 while cutting. Breakage occurred from this corner at the beginning of the cutting operation without resisting the stress.

In contrast, in the tools of sample Nos. 9 through 12 of the present
- 10 invention, cutting could be carried out during its long life while preventing breakage to occur at the beginning of the cutting.

(Embodiment 3)

The hard sintered body indexable insert having the structure shown in
15 Figure 1 that had been obtained from the composite hard sintered body was made. The entire thickness of the hard sintered body indexable insert was 4.76 mm, and the thickness of the tool substrate between the seating grooves was 2.66 mm. The composite hard sintered body used in this example contained cubic boron nitride by 50 vol %, and the thickness of the hard
20 sintered body and that of the cemented carbide support were each 1 mm.

A paste-like brazing alloy was prepared by mixing a powdery brazing alloy which contains 2 wt % Ti and 26 wt % Cu and the remainder of Ag and inevitable impurities with gelatin. Thereafter, the composite hard sintered

According to the present invention, machining costs for one cutting edge of the hard sintered body can be reduced, and the tool substrate can be effectively used. In other words, a hard sintered body indexable insert can be provided which is excellent in performance and in durability and which leads to cost-efficiency.

According to the present invention, machining costs for one cutting edge of the hard sintered body can be reduced, and the tool substrate can be effectively used. In other words, a hard sintered body indexable insert can be provided which is excellent in performance and in durability and which leads to cost-efficiency.